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INTRODUCTION

Digital computer maps were used to prepare the 1996 Census collectors' maps. These data are also the source of digital map data used in 1996 Census products.

This information paper explains how the digital map data were created and used. The paper was prepared by Martin Brady of the ABS, with contributions from John Allen and Anthony Davis of the ABS, and John Mobbs, of the Public Sector Mapping Authority (PSMA).

Part A provides a broad picture of the 1996 Census digital geographic data and products. Part B contains more detailed information about how the various digital datasets were produced. Part C contains details of 1996 Census geographic products.

For readers requiring a historical context, see Appendix A.

Italicised terms are defined in the publication *1996 Census Dictionary* (2901.2). Note that only the first occurrence of these terms is italicised.

PART A OVERVIEW

CENSUS DIGITAL GEOGRAPHIC INFORMATION

The ABS has made available vector based digital geographic information for the Australian Census of Population and Housing (the Census) in various forms since the 1976 Census. Before the 1996 Census the purpose of this *digital geographic information* has been to facilitate display and analysis of census and other ABS data in *desktop mapping packages* and *geographic information systems (GIS)*. The 1996 Census has seen some major steps forward for the ABS in the way that digital geographic information is produced and used by the Census Program.

The ABS has, for the first time, been directly involved with the preparation of digital geographic information used in the 1996 Census. The first use of these data was in the Collection Mapping System (CMS), where digital boundaries for the *Census Collection Management Areas* were produced based on an underlying *digital base map*. The digital boundaries created in the CMS were then used in conjunction with the digital base map to produce high quality census collection maps for census field workers.

The second use for the digital base map, boundaries and associated aspatial data (attributes) has been in many of the geographic products produced for the 1996 Census. For example, the boundaries for collection management areas created by the CMS are used to create digital boundaries for the Census Geographic Areas (listed in Appendix C), for which census statistical data are disseminated. The common link between collection areas and *Census Geographic Areas* is the *Census Collection District (CD)*.

CENSUS COLLECTION MAPPING SYSTEM (CMS)

The base map used in the CMS had to provide a seamless coverage of the whole of Australia. It also had to contain sufficiently detailed *topographic and cadastral features* to allow accurate definition of the collection boundaries by the boundary designers as well as fulfil specific requirements for use in the collection maps, such as determining collector routes.

The *Public Sector Mapping Agencies (PSMA), Candata,* and the ABS, cooperated in a joint project to produce a digital base map that fulfilled these requirements.

The development and execution of this project has been one of Australia's largest involving digital geographic information of this type. Through the direct involvement of the ABS in this project, and as a result of the precise census collection requirements, the quality and detail of the digital geographic information produced is unsurpassed by any similar dataset covering the whole of Australia.

The system was built and used to facilitate:

- the design of collection boundaries;
- the production of census collection management area maps which integrated the collection boundaries and the base map data;
- management of the information associated with boundaries; and
- storage of the digital geographic information used.

The CMS used the following software to manage and manipulate the data:

- Oracle, as its primary database management system;
- Intergraph's MicroStation, as the graphics engine; and
- MicroStation Modular GIS Environment System (MGE), to link the spatial data to the aspatial data.

The digital geographic information produced, including the base map, was incorporated into the Master Spatial Database (MSD). These same data will be used as input into the collection design process for the 2001 Census.

Appendix B contains more detail about the CMS.

SPATIAL DATABASES

ABS digital boundaries and associated aspatial data have been combined with the PSMA base map to create an integrated dataset called the Master Spatial Database (MSD). In its entirety, the MSD contains approximately 6 gigabytes of data. The ABS has produced three output databases from the MSD. These three databases are the source of the 1996 Census Digital Geographic Information Products.

Output Spatial Database (OSD)

This contains all the data in the MSD except the digital cadastral data and the census collection management area boundaries. The majority of features contained in the database are named by proximate text elements, which are stored as distinct graphic elements in the database. Some topographical features are also attributed with name and feature-classification details. The OSD is approximately 5 gigabytes in size.

At the time of printing this publication, the OSD requires further enhancement before it is possible to derive products of an acceptable quality.

Reduced Output Spatial Database (ROSD)

This contains a selected range of topographic features from the OSD (features have been selected based on their usefulness when used in conjunction with census statistical data and digital boundaries). These selected features have been filtered, that is they have been reprocessed and the number of points per linear and area feature has been reduced, to reduce their storage size. The CD boundaries have also been filtered to an average of 2,000 points per boundary. Boundaries for the other Census Geographic Areas have also been filtered.

For users of MapInfo and other mapping packages which limit the number of points which a polygon can contain, some of the higher level boundaries (for example Statistical Subdivision and higher) will exceed the capacity of the software. In this case Shapes boundaries should be used. In the case of CDATA96, such boundaries will be further filtered so that they can be displayed in MapInfo, however, boundaries so filtered will not align with the CD boundaries or the base map features accurately.

Following the initial creation of this database, significant resources have been put into enhancing the quality of the ROSD.

Additional name attribution has been added to the features in the database. Note that street addresses and street address range data are not available in this database nor any other ABS product. The total size of the ROSD is about 650 megabytes.

Shapes Output Spatial Database (SOSD)

This contains a set of digital boundaries for the Census Geographic Areas that have been greatly filtered to create approximate representation of boundaries. These shape boundaries are intended for use only in low-end mapping packages, such as those included in *Excel 95* and *Lotus 1–2–3*. Boundaries in this database have been reduced to an average of 200 points. This database does not include any digital base map data.

For more detail about the ABS Spatial Databases see Part B below.

PRODUCTS

The ABS has endeavoured to ensure that the data produced provide the maximum benefit to the Australian community. The following products are sourced from the databases discussed above:

- 1996 Census All-Points Boundaries
  These boundaries are sourced from the OSD. At the time of printing this publication, the OSD requires further enhancement before products of suitable quality can be produced.

- 1996 ABS/PSMA All-Points Base Map
  The PSMA may make this product available (refer to the contact list at Appendix I).

- 1996 Census Reduced Boundaries
  This product incorporates the full range of boundaries for which census statistical data are available. Although the detail has been reduced from the original, these boundaries are still highly accurate. Whether used alone, or in conjunction with the matching ABS/PSMA base map, they provide the most accurate base for displaying ABS Census data ever provided. They are suitable for use in many applications.

  These boundaries are sourced from the ROSD. In terms of amount of data, these boundaries are roughly comparable to the 'Standard' boundaries provided from the 1991 Census. The accuracy, however, is significantly better.

  For users of GIS or Mapping Systems which do not limit of the number of points per polygon or region, all higher level aggregated boundaries (for example. Statistical Divisions) align exactly with the CDs in this product. The equivalent boundaries from the 1991 product did not because of CDATA91 system limitations.

  For users of MapInfo and other mapping packages which limit the number of points which a polygon can contain, some of the higher level boundaries (for example Statistical Subdivision and higher) will exceed the capacity of the software. In this case Shapes boundaries should be used.

For MapInfo, a special set of further reduced boundaries are available for the affected higher level areas - these boundaries are more accurate than Shapes boundaries but will not accurately fit the Reduced CD boundaries or the ABS/PSMA Reduced Base Map.

For other software with point capacity limitations, either the special MapInfo set (above), or Shapes boundaries can be used.

- 1996 ABS/PSMA Reduced Base Map
  This product has been tailored for use in providing census data users with a highly accurate and detailed digital map. It is also suitable for other applications requiring a digital base map. The PSMA may make this product available (see Appendix I).

  The feature and point reduction which has occurred in the production of this database reduces it to a manageable size. The point reduction employed has had little effect on the overall accuracy of the product.

  It incorporates all the topographic features contained in the ROSD set. The base map aligns with the 1996 Census Reduced Boundaries. These base map data are roughly comparable to the detailed base map data available with CDATA91.

- 1996 Census Shapes Boundaries
  This product incorporates the full range of boundaries, for which census statistical data are available, at a greatly reduced level of detail. These boundaries are sourced from the SOSD.

- CDATA96This product incorporates 1996 Census Reduced Boundaries, Census aspatial and statistical data, and software which supports the display and analysis of the geographic and statistical data. Limited information from the 1996 ABS/PSMA Reduced Base Map is also provided in the standard version. **The complete 1996 ABS/PSMA Reduced Base Map is also available as an add-on module.** For information about the use of more detailed base map data with CDATA96, contact the ABS (see Appendix I).

- MapInfo is the mapping engine in CDATA96. MapInfo limits the number of points which a polygon can contain, some of the higher level boundaries (for example Statistical Subdivision and higher) exceed the capacity of the software. In CDATA96, such boundaries will be further filtered so that they can be displayed in MapInfo, however, boundaries so filtered will not align with the CD boundaries or the base map features accurately.

- 1996 Census Standard Reference Maps
  There are two types of full colour reference maps available: 1996 Census Collection District (CD) Maps and

1996 Census Statistical Local Area (SLA) Maps. CD maps show the location and coverage of each 1996 Census Collection District (CD) — fully detailed topographic features, including names (e.g. street names) are also mapped.

- Maps in 1996 Census publications
  The 1996 Census Social Atlas series and several of the 1996 Census statistical publications contain maps which use 1996 Census digital geographic information.

- ABS Client Services
  A range of services is available that incorporates 1996 Census digital geographic information, including: customised geographic data reports, customised thematic maps and customised reference maps.

The 1996 Census Boundaries, listed above, are available to ABS clients in standard industry formats from a network of secondary providers licensed by the ABS to distribute these products. The ABS/PSMA Reduced Base Map is available as an add-on module in CDATA96. The ABS/PSMA All-Points and Reduced Base Maps may also be available separately from the PSMA. A list of secondary providers can be obtained from the ABS (see Appendix I).

For more detail about census products which incorporate 1996 Census digital geographic information, see Part C below.

MAJOR CHANGES FOR THE 1996 CENSUS

Before the 1996 Census, the ABS produced digital geographic information to add further value to the data coming from the Census and many of its other data collections. This digital geographic information had very few other uses. Appendix A outlines the ways in which digital geographic information has been prepared and used in the past, as well as a broad outline of other geographic products from previous censuses.

The ABS has made some significant advances in the use of digital geographic information in the collection and dissemination of 1996 Census data. These steps forward are either directly or indirectly a result of changes to the census collection mapping program that were implemented shortly after the 1991 Census.

PART B

1996 CENSUS DIGITAL GEOGRAPHIC DATABASES

RELATIONSHIP BETWEEN 1996 CENSUS DIGITAL GEOGRAPHIC DATABASES

This section provides detailed information about the 1996 Census Digital Geographic Databases, what they contain, how they differ, and where the various products are sourced.

The Master Spatial Database (MSD) is the centralised and standardised store for the geographic data which originated from the 1996 Census mapping project.

The digital geographic data made available to the public from the 1996 Census are not taken directly from the MSD, but extracted from three other databases — Output Spatial Database (OSD), Reduced Output Spatial Database (ROSD), and Shapes Output Spatial Database (SOSD). Most of the information contained in these databases was sourced from the MSD.

MASTER SPATIAL DATABASE (MSD)

The MSD is used:

- as the data source for the output databases; and
- to store the geographic data which will be the primary input into the collection management area work that will be required for the 2001 Census.

The MSD comprises the data from the Collection Management System (CMS), the Census Geographic Area boundaries (i.e. boundaries other than the CD boundaries), and some census statistical data.

The MSD is the primary database of geographic data. All census products are produced from the OSD, ROSD and SOSD, which are all primarily sourced from the MSD. In total it is approximately 6 gigabytes in size.

The MSD itself contains three fully integrated elements:

- digital base map data;
- digital boundary data; and
- the CD Record Database (CDRD).

The three integrated elements have their data broken into two broad categories of data — spatial data and aspatial data. The digital base map and digital boundary data incorporate both spatial and aspatial data. The CDRD only incorporates aspatial data.

Refer to Appendix D for detailed information about spatial and aspatial data.

MSD Digital Base Map

The spatial data in the base map were supplied by the PSMA and was initially used in the CMS, as described above. Some of the aspatial data, mostly the basic name attribution discussed below, were supplied by the PSMA. The remainder were generated through the CMS.

Refer to Appendix E for detailed information about the quality of the digital base map data.

The MSD contains about 6 gigabytes of digital base map data, made up of two distinct elements: digital topography and digital cadastre. The topographic data were supplied in separate files to the cadastral data.

Digital topography

The PSMA created the topographic dataset through contributions from each of its members — principally the State and Territory Mapping Authorities and the Australian Surveying and Land Information Group (AUSLIG). As a result the data were sourced from maps of varying scales.

The data supplied for each State or Territory depended on the databases and maps held by the particular agency at the time. Where data were not available for a particular region within a State or Territory, AUSLIG's GEODATA TOPO 250K Base Map was used. GEODATA was generally only used in remote areas. The map contained in Appendix F is a generalised depiction of the source scale of maps used to create the digital topographic data stored in the database. The majority of areas covered by towns and cities within the GEODATA-sourced regions were supplemented with more detailed map data from larger scale coverage.

The PSMA greatly accelerated their data capture programs for this project to ensure that the base map coverage would be as comprehensive, accurate, detailed and up-to-date as possible, given the time constraints imposed by the census collection operations.

The MSD base map contains a number of different topographic features, including: roads, schools, national parks and many others. A full list of the features contained in the digital topography is included in Appendix H.

LOCATION OF TEXT AND SYMBOL ELEMENTS IN BASE MAP DATA

The majority of topographic features in the database are named by proximate text elements, i.e. their location is indicated by the presence of a text or symbol element. Both possible representations are shown above. The text and symbols are graphic elements in the base map, they are not stored as attributes of the features. (Name attributes have, however, been included in the ROSD — see below for further information.)

Because of time constraints, name attribution was restricted to highways, major roads, and major rivers. Each of the features that fall into these classifications is attributed with name (e.g. Bruce Highway) and feature classification (e.g. highway). Attribution is achieved through linking a MicroStation Modular GIS Environment (MGE) attribute table to each linear element that makes up the feature. The attribution can then be used as a means of creating a database query or search.

The topographic data are stored by the ABS in MicroStation design files within a MGE project.

Digital cadastre

Digital cadastral linework was supplied in separate files to the topographic data. This information was only for use to enhance the maps used by collectors, and is not used in any products for dissemination (except the 1996 Census CD Maps — see Part C). Digital cadastral linework was also used to generate some road casement detail. Full detail digital cadastral data can be obtained by contacting the PSMA in the relevant State or Territory (refer to the contact list at Appendix I).

The cadastral data are stored in MicroStation design files.

Tiling

The base map data were supplied to the ABS in base map tiles, that is, the area of Australia was split up into rectangular blocks, and the base map was supplied in those blocks. The edges of each of the tiles in the dataset were matched with adjoining tiles to ensure that a seamless base map covering the whole of Australia could be created from these blocks. Diagrams depicting tile coverages are available from the PSMA (refer to the contact list at Appendix I).

MSD digital boundaries

The digital boundaries stored on the MSD align with the ABS/PSMA base map data and they are about 150 megabytes in size.

Refer to Appendix E for detailed information about the quality of the digital base map data.

Digital boundaries include the collection management area boundaries and the full range of Census Geographic Area boundaries produced for the dissemination phase of the 1996 Census. A full list of boundary types that fit into these two categories is included in Appendix C.

The digital boundaries for the Census Geographic Areas were generated using the CD boundaries created in the CMS, and aspatial data stored on the CDRD. CDs belonging to a particular area, say an SLA, were identified. A copy of all the boundaries for these CDs was taken, then the internal boundaries were deleted, leaving only the exterior boundaries, i.e. the SLA boundary. A similar process to this was followed for all the other areas.

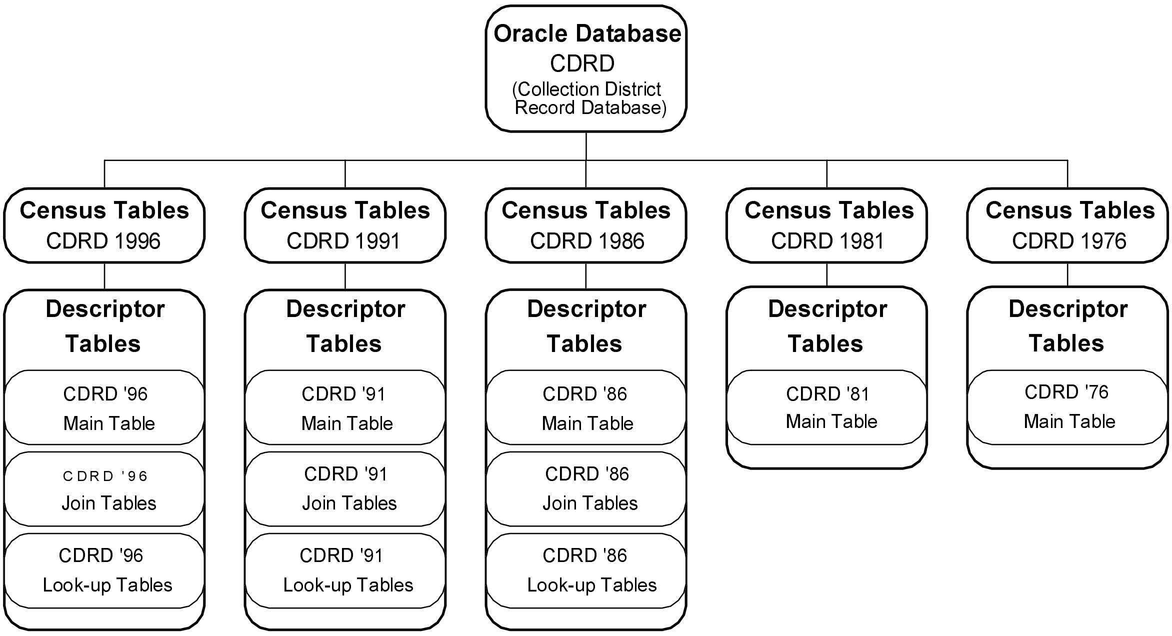
A table containing the names and codes for that area, and larger areas, was also created. Each record in this table is linked to the spatial data that define the area's boundary.

Note that the prime use of such detailed boundaries was to ensure Census collectors' maps were as accurate as possible. Such detailed boundaries were suitable for use in the production of collector's maps, but are not, at the time of printing this publication, suitable as a digital map product. See ROSD for more information on available boundaries.

COLLECTION DISTRICT RECORD DATABASE (CDRD)

The CDRD is an Oracle (relational) database containing a wide range of aspatial data which are associated with the boundary spatial data. The primary database tables relate to the 1996 Census, but data from as far back as the 1976 Census will eventually be included in the database. There are also join tables that allow the main tables from each census to be linked to allow comparison of areas from different censuses — important for time series work. The diagram below shows how these different tables are interrelated.

CDRD STRUCTURE



Main tables

Each of the 1986, 1991 and 1996 CDRD Main Tables contain:

- the CD number and type (Aboriginal Community, Alpine CD, etc);
- the codes indicating the Collection Management Areas and the Census Geographic Areas to which the CD belongs;
- the area of the CD in hectares;
- various latitude and longitude characteristics of the CD, including the *centroid*; and
- a limited range of census counts for that CD.

The amount of information contained in the 1976 and 1981 CDRD Main Tables is restricted to:

- the CD number;
- a limited range of Collection Management Area and the Census Geographic Area codes; and
- a limited number of census counts.

Look-up tables

The look-up tables provide textual descriptions of some of the codes contained in the main tables. For example, a CD may be assigned to an SLA (SLA code 4100 and State Code 1) in the 1996 Main Table. In the 1996 Look-up Tables the SLA code 4100 is linked to the name Hunters Hill, NSW.

The CDRD holds look-up tables for fields in only the 1996, 1991 and 1986 Main Tables. These look-up tables contain textual descriptions for all the Collection Management and Census Geographic Area codes and for the variable CD Type.

Join tables

Join tables are designed to link each of the census year main tables and provide time series information on CDs. They indicate which CDs, from the different censuses, are equivalent, as well as the degree of comparability between CDs. This is necessary because many CDs undergo some type of change between each census. The types of changes that can occur include:

- splitting a CD into two or more new CDs;
- amalgamating two or more CDs into a new CD; and
- varying the boundary of an existing CD.

As an example, the 1996/1991 Join Table contains:

- all 1996 CD codes;
- the 1991 CD codes that each 1996 CD is comparable (or not comparable) to; and
- a *comparability code*, which is linked (via a look-up table) to an explanation of the meaning of that code (for example, code 3 means, that the 1996 CD is comparable within a 10% dwelling limit to the 1991 CD).

OUTPUT SPATIAL DATABASE (OSD)

The OSD was drawn directly from the MSD, so the data it contains are at the same level of detail as that contained in the MSD. The OSD is the source of the 1996 Census All-Points Boundary and the 1996 ABS/PSMA All-Points Base Map products and the source of CDRD data. used in 1996 Census Customised Geographic Data Requests. The OSD is approximately 3 gigabytes in size.

There are some differences between what is available in the OSD and what is stored on the MSD.

OSD digital base map

The cadastral data is not included on the OSD base map. These data were only licensed to the ABS by the PSMA for use in the Collection Maps. All the topographic data contained in the MSD digital base map (listed in Appendix H) is included in the OSD Base Map. While the cadastre is not present and only the topographic data remains, the data is still referred to as the 'base map'. Removal of the cadastre data reduced the size of the MSD base map by approximately one half.

The base map remains tiled and each tile is stored in a MicroStation design file. The limited attribution contained in the MSD was carried across to the OSD.

The 1996 ABS/PSMA All-Points Base Map is sourced from the OSD and may be made available by the PSMA (refer to the contact list at Appendix I). The PSMA may also make the cadastre available for various areas.

OSD digital boundaries

All boundaries on the MSD were carried across to the OSD except the Field Management Areas and the Field Group Areas. (These are equivalent to the Census Division and Census Subdivision boundaries of previous censuses). Census and other ABS data are not released for these two areas and they are not included in the Australian Standard Geographic Classification (ASGC). Appendix C contains a list of these areas.

The OSD is the source of the Census All-Points boundaries.

The linkages between the boundaries on the MSD and the data on the CDRD were retained in the OSD.

CDRD

The CDRD information linked to the OSD is limited to that required for data dissemination and analysis. Data items that were required for the purposes of managing the census collection operation were excluded.

The only census counts available are total males, total females and total number of dwellings.

A list of the data items contained in the OSD version of the CDRD is contained in Appendix G.

Data quality

The differences between the MSD and the OSD result from omitting particular parts of the MSD. As a result there are no additional logical consistency errors, or display anomalies. Therefore the data quality remains effectively the same as MSD. See Appendix E.

REDUCED OUTPUT SPATIAL DATABASE (ROSD)

The ROSD was constructed by reprocessing data which were drawn directly from the OSD. This reprocessing reduced the size of the database to approximately 650 megabytes. Because this database is the source of most map-based census products, substantial resources were put into enhancing the quality. Some additional name attribution was also added to the base map dataset. This name attribution was obtained from, and added, by MapInfo Australia, on behalf of the PSMA.

The main reason for producing the ROSD was to produce an integrated set of boundaries and base map features with suitable performance and file size characteristics for use in desktop mapping packages such as CDATA96. To achieve this the the digital data, drawn from the OSD, were altered in the following three ways:

- several non-essential classes of base map feature were removed;
- the number and content of Oracle tables containing attribute and systems data were rationalised — a process generally referred to as thinning; and
- the number of points representing each linear and area feature, in both the boundary and base map data, were reduced — a process generally referred to as filtering.

In this publication the combination of the three alterations, listed above, is referred to as database reduction, or simply, reduction.

The resulting data remain very accurate, and provide good performance characteristics with many desk-top mapping packages and geographic information systems (GIS). The 1996 ABS/PSMA Reduced Base Map may be made available by the PSMA (refer to the contact list at Appendix I).

To understand the thinning and filtering process discussed below, it is necessary to understand the nature of the digital geographic information contained in the ABS digital geographic datasets — see Appendix D.

Removal of base map features

The base map supplied by the PSMA was designed to suit the requirements of the Collection Management System, to ensure that boundaries could be clearly aligned with 'real world' features, and that maps produced would allow collectors to easily identify boundaries and plan routes in collections areas. Therefore detailed features such as, powerlines, minor drainage features and lane ways, were included in the MSD base map.

For statistical analysis packages such as CDATA96 that use digital geographic data, this fine level of topographic detail is not generally required. The content of the data was therefore rationalised to only include those base map features which would be useful in identifying the general location of a boundary or a set of boundaries, or which would assist in the analysis of census data.

The base map features included in the ROSD are indicated in Appendix H.

Database thinning

The digital geographic databases contain a number of Oracle tables that store various attribute data which are linked to the spatial data. Much of this attribute data were not required for use in the ROSD.

Only the most basic information that linked directly to the boundaries in the CDRD tables was retained.

Some of the remaining attribute data were reorganised so that many data redundancies were removed, making the storage of the data more efficient. Redundancies in the original database were permitted as they allowed faster processing and system operation at the ABS.

Filtering

The fundamental elements in any vector based spatial database are the points and lines which define the geographic features. These elements also make the biggest contribution to the size of the database. Therefore to reduce the size of a database, an effective option is to reduce the number of points and lines representing each of the features. Obviously this is not a valid option for point features as there is only a single point defining each feature; but for line and area features this can be quite effective in reducing the size of the database. The main disadvantage of this process is that the representation of the geographic features in the filtered database is no longer as detailed as their portrayal in the original database. There is therefore a need to trade off detail, and hence spatial accuracy, against the functionality limitations of large digital spatial databases.

When filtering a database, the reduction in the detail and positional accuracy with which a feature is represented increases as fewer points are used to represent that feature. As more points are removed, the more generalised a feature becomes, and the less accurate the representation of its position. The influence that filtering has had on positional accuracy, and the subsequent quality and usefulness of the ROSD, was a major consideration in the design and execution of the filtering process.

To minimise the detrimental effect of filtering, the majority of points removed were taken from features that were represented by large numbers of points compared to the distance or area covered. In general, curved features fit this description. Filtering reduces the number of points making the curve less smooth but does not greatly detract from the representation of the feature. Water features such as coastline, lakes and rivers streams were generally the most effected by thinning.

When the CD boundaries were constructed in the Collection Mapping System they were generally aligned to topographic features, as represented in the digital base map. To ensure that the boundaries continued to be accurately aligned to the correct base map features in the ROSD, the same points were removed from the CD boundaries as were removed from the base map features that defined them. For example, a CD boundary in the OSD that followed a section of a river would have the same points removed from the boundary as were removed from the part of the river it followed.

This process resulted in filtered CD boundaries that perfectly matched the filtered topographic features. The other Census Geographic Area boundaries were then regenerated using the filtered CD boundaries.

The filtering process itself was largely automated, however extensive quality assurance was done on the digital geographic information produced. The main goals of the quality assurance procedures were to:

- check that the representation of the topographic features in the base map were still of an acceptable quality;
- ensure that the CD boundaries were aligned to the topographic features correctly; and
- ensure that the other Census Geographic Area boundaries were regenerated correctly.

Alternative ROSD higher level boundaries

The higher level Boundaries (eg, Statistical Divisions) aggregated from CDs genrally contained more than the 2000 points that the CD boundaries were limited to. This was due to two factors; the higher level boundaries cover larger land areas, and they genrally follow features that contain large number of points to define them (such as coastline and rivers).

For some GIS and Mapping Packages the number of points per feature is limited and as such polygon or region elements cannot be produced from the ROSD boundaries because of the higher numbers of points per boundary. To facilitate use of the ROSD boundaires in CDATA96 a set of higher level boundaries have been produced so that the number of points per goegraphic is less than 32,000 (adjust when a decision is made) points per polygon. These boundaries will be made available to users who wish to use them.

The higher level boundaries created were those above the SLA and LGA level in the ASGC hierarchy (see diagram X) and Commonwealth Electoral Divisions. These alternative boundaries however will not allign exactly with those boundaries at or below the SLA/LGA level, including the CD boundaries. They will also not allign exactly with the basemap features that underly them. Positional accuracy data will not be available for these alternative boundaries.

For those users that cannot utilise this alternative set of boundaries, a third final set of boudnaries are available - the shapes boundaries (discussed below).

Base map feature attribution

A further requirement of the ROSD was that it provided a base map that contained name attributed features equivalent to that available in CDATA91. This attribution permits the identification or selection of specific spatial features (such as, streets and schools) based on the name of that feature. The limited number of features on the OSD that were attributed and were included in the ROSD was not sufficient to fully meet this requirement. The PSMA entered into an agreement with MapInfo Australia to attribute the spatial data in the 1996 ABS/PSMA Reduced Base Map.

Note that this additional name attribution is only available in products produced from the ROSD. It is not currently available from any products from the OSD.

The process of attributing the reduced base map was largely automated and the PSMA implemented a number of quality assurance procedures to ensure that the transfer of attribution was as accurate as possible. The attribute information transferred included the category each feature belonged to (e.g. Sealed Road) and the name of that feature (Australia Street). See Appendix H for a list of features that were attributed.

Data quality

The filtering process used in the creation of the ROSD thus reduced the positional accuracy of the base map features. This also effected the positional accuracy of the boundary data. See Appendix E for detailed information about data quality.

During the reduction process, some adjustments were made to the ROSD base map and boundary data to correct some minor problems. At the time of printing of this publication, the intention is to eventually carry these corrections through to the OSD and MSD.

SHAPES OUTPUT SPATIAL DATABASE (SOSD)

The SOSD contains only digital boundaries, i.e. no base map data are included. The boundaries in this database are further filtered versions of the boundaries contained in the ROSD. These boundaries are only crude representations of the actual boundaries and should only be used where accurate boundary detail is not a major consideration, such as in broad level thematic mapping.

These 'Shapes Boundaries' are primarily intended for use in the mapping modules included in spreadsheet packages such as *Excel 95* and *Lotus 1–2–3*.

The benefits of using these 'Shapes Boundaries' compared to those contained in the ROSD are:

- faster on-screen display of maps; and
- reduced storage requirements.

This is because the system has fewer individual line segments per boundary to store, plot, draw and incorporate in other system calculations.

The Shapes Boundaries were produced using similar techniques used to create the boundaries in the ROSD. However all of the boundaries from the ROSD underwent additional filtering to ensure that on average each CD and higher level Shape Boundary contains about 200 points each. This figure compares to about 2,000 points for the CD boundaries in the ROSD.

PART C

CENSUS GEOGRAPHIC PRODUCTS

1996 CENSUS DIGITAL BOUNDARIES

The 1996 Census Digital Boundaries facilitate the analysis and display of 1996 Census statistical data through their use in various software packages. Statistical data from other ABS collections, or from other sources, can also be used in conjunction with these boundaries. However the geographic areas on which the data are based must concord with the 1996 Census boundaries.

The 1996 Census Digital Boundaries are available in two types:

- 1996 Census Reduced Boundaries; and
- 1996 Census Shape Boundaries.

At the time of printing this publication, the ABS cannot provide any release details of the 1996 Census All-Points Boundaries.

1996 Census Reduced Boundaries

The 1996 Census Reduced Boundaries are currently the most accurate and suitable boundaries available for use with 1996 Census data. These boundaries were drawn from the ROSD (see Part B above). These boundaries are intended for use in GIS and desktop mapping packages. 'Low-end' mapping modules, such as those included in *Excel 95* and *Lotus 1–2–3*, are capable of using these boundaries, however, display speeds may be fairly slow. The 1996 Census Reduced Boundaries align with the 1996 ABS/PSMA Reduced Base Map. They do not accurately align with any other digital base map (see Use with alternative digital base maps, below).

For users of GIS or Mapping Systems which do not have a limit of the number of points per polygon or region, all higher level boundaries (for example. Statistical Divisions) align exactly with the CDs in this product.

For users of MapInfo and other mapping packages which limit the number of points which a polygon can contain, some of the higher level boundaries (for example Statistical Subdivision and higher) will exceed the capacity of the software. In this case Shapes boundaries should be used. In the case of CDATA96, such boundaries will be further filtered so that they can be displayed in MapInfo, however, boundaries so filtered will not align with the CD boundaries or the base map features accurately.

For MapInfo, a special set of further reduced boundaries are available for the affected higher level areas - these boundaries are more accurate than Shapes boundaries but will not accurately fit the Reduced CD boundaries or the ABS/PSMA base map.

For other software with point capacity limitations, either the special MapInfo set (above), or Shapes boundaries can be used.

In the case of CDATA96, such boundaries will be further filtered so that they can be displayed in MapInfo, however, boundaries so filtered will not align with the CD boundaries or the base map features accurately.

While they both types of Reduced boundaries are suitable for statistical analysis and many other applications, they are not suitable for highly detailed spatial analysis involving attributes that are highly dependant on area and extent factors. Clients concerned with the issues of data quality and spatial accuracy should read Appendix E.

1996 Census Shape Boundaries

The 1996 Census Shape Boundaries are a version of the 1996 Census Reduced Boundaries that have undergone further filtering. These boundaries have been drawn from the SOSD (see Part B). The boundaries have been specifically created for use in 'low-end' mapping modules such as those included in *Excel 95* and *Lotus 1–2–3* where the low number of points used to create these shape boundaries enable much faster display speeds. GIS and desktop mapping packages are able to use these boundaries but the limitations described below should be considered in all uses. The 1996 Census Shapes Boundaries do not align with the any of the 1996 ABS/PSMA Digital Base Maps.

The extent and area of these Shapes Boundaries have been significantly altered by the additional filtering used to produce them. Due to these changes they should not be used for any analysis involving extent or area attributes derived from the spatial data. Area data for any of the geographic areas represented by the Shapes Boundaries can be obtained from ABS Client Services (refer to the contact list at Appendix I). The boundaries should also only be used for broad level thematic mapping. If used for detailed mapping purposes, extrapolation of boundary detail is not valid.

Dissemination of boundaries

The dissemination of the 1996 Census Digital Boundaries is through a network of ABS appointed secondary providers. Each secondary provider has a non-exclusive license to distribute, and provide after sales support for, a set of nominated file formats. It has been the intention of the ABS that all common industry formats be covered by at least one supplier with experience in that format.

To obtain a set of boundaries a customer should:

- determine the region for which the boundaries are required;
- determine whether Reduced, or Shapes Boundaries are required for the particular application;
- determine which Census Geographic Area is required (for example, CD or SLA — see Appendix C for a list of available boundaries);
- determine the file format required by the software being used; and
- obtain a list of ABS appointed secondary providers and the file formats which they service (obtained from ABS Client Services) and contact the appropriate one.

Boundaries are only supplied to secondary providers as a complete set for each State and Territory. Clients requiring boundaries for areas smaller than a State or Territory need to inquire if the particular secondary provider supplies the boundaries for these areas.

The price customers are charged for the boundaries varies between file formats and possibly between secondary providers. This occurs because it is the secondary providers who perform the conversion into the appropriate file format/s, and the complexity of this process varies depending on the format. Additional costs may be incurred if boundaries for specific regions are required.

Statistical data for use in conjunction with the 1996 Census Digital boundaries can be obtained from ABS Client Services (refer to the contact list at Appendix I). Data from the 1996 Census are progressively available from July 1997. Data from other ABS statistical collections may be able to be used with these boundaries, depending on concordance with 1996 Census boundaries, and are available at various times. Clients should contact ABS Client Services for the release dates of data and to determine if those data are compatible with the 1996 Census boundaries.

Use with alternative digital base maps

The 1996 Census Digital Boundaries may be used in conjunction with base map data other than the recommended ABS/PSMA base map, however, alignment of boundaries to these alternative base maps cannot be expected. This is due to three factors:

- if the alternative base map is not derived from the same digitising source then the points defining each of the corresponding features will be different and the boundaries will not align perfectly;
- the original ABS/PSMA base map is spatially accurate to specific tolerances (see Appendix B for data quality information). If an alternative base map has different spatial accuracy characteristics then the boundaries cannot be expected to align; and
- the Shape and Reduced Boundaries have undergone filtering which has reduced their spatial accuracy. This substantially reduces the likelihood that these boundaries fit an alternative base map. This effect increases with the level of filtering.

Copyright on boundaries

The copyright and intellectual property rights for the 1996 Census Digital Boundaries are retained solely by the Commonwealth of Australia and are administered by the ABS. Any use of the boundaries is subject to a standard licence agreement to be signed by parties purchasing the boundaries.

1996 ABS/PSMA BASE MAPS

The ABS/PSMA Reduced Base Map is available as an add-on module in CDATA96. The ABS/PSMA All-Points and Reduced Base Maps may also be available separately from the PSMA.

Inquiries regarding use of the base map in CDATA96 should be directed to the ABS. Refer to the contact list at Appendix I.

Inquiries about copyright on the ABS/PSMA base maps **can** be directed to **either the ABS or** the PSMA (refer to the contact list at Appendix I).

Detailed product information, such as quality indicators and content details, can be obtained from the PSMA, or in the case of CDATA96, the ABS.

CDATA96

CDATA96 offers ABS clients a package of 1996 Census Digital Boundaries and 1996 Census data integrated with software which facilitate the manipulation of both digital geographic data and statistical data. A limited range of features from the 1996 ABS/PSMA Reduced Base Map is included in CDATA96. For information about the use of more detailed base map data with CDATA96, contact the ABS (see Appendix I).

CDATA96 is a CD ROM based product that packages both the software and data onto CD ROM. The software selected for CDATA96 is MapInfo for Windows and the product runs within Microsoft Windows 32 bit operating systems (Windows 95 and Windows NT). The digital geographic and statistical data included in CDATA96 can cover either the whole of Australia or individual States/Territories.

CDATA96 continues the product line from the CDATA86 and CDATA91 products. CDATA is widely used by government, retailers, advertisers, market researchers, libraries, charities, town planners, financial institutions, and others who need a powerful community profiling tool. Areas of use include site location, market penetration, regional profiling and sales territory definition.

For more information about CDATA96, contact the ABS (see Appendix I).

1996 CENSUS STANDARD REFERENCE MAPS

The 1996 Census standard reference maps incorporate two sets of maps: the 1996 Census SLA Maps and the 1996 Census CD Maps. These are paper maps. They are printed for the ABS, as required, by the New South Wales Land Information Centre (LIC) at Bathurst.

Note that these are reference maps, which do not contain any statistical data.

1996 Census SLA Maps

There is at least one map sheet for each 1996 Census SLA. Each map shows the boundary of an SLA and the CD boundaries contained within. The name and code of the SLA are included, as well as the CD codes. Some boundary detail for the surrounding SLAs is also included. The following selected topographic details, obtained from the OSD (see Part B, above, and Appendix H.1), is also included in the maps:

- roads — roads coincident with CD or SLA boundaries are named;
- water-based features — major water features are named;
- railway lines and stations — prominent lines and stations are named;
- airports and landing strips — some include names;
- parks and reserves — significant parks and reserves are named;
- significant physical features, such as mountains;
- major cultural features, such as schools and prominent structures such as radio and water towers; and
- other major cultural/physical features, such as transmission lines, jetties, pipe lines and fences that are required to define CD boundaries — some prominent features are named.

Note that for larger scale maps, some of these features are omitted for clarity.

There are approximately 2,600 SLA map sheets. Each map sheet is printed on an A3 sheet. Some SLAs are too large to fit on a single A3 sheet. The area of these SLAs has been split over two or more A3 map sheets. These map sheets can be fitted together to create a single representation of the SLA. For some maps additional map sheets, containing insets, are supplied. These insets show enlargements of more densely populated areas.

The scale of each map is set so that the area covered by the SLA is maximised on the available sheet area. Maps are therefore not all the same scale. Maps split over two or more sheets are at the same scale.

1996 Census CD Maps

The 1996 Census CD Maps are the same maps that were used by census collection staff during the collection phase of the 1996 Census. Each map shows an individual CD's boundary and the code assigned to it. Some boundary detail for the surrounding CDs is also included in the map. All census CDs have at least one map sheet covering their area. The maps also show a range of topographic and cadastral features. These features give the boundaries their context and show how they are used to define the CD boundaries. The topographic and cadastral data included in the maps is obtained from the MSD.

There are approximately 46,000 CD map sheets. Each map sheet is printed on either an A4 or an A3 sheet. Some CD Maps were originally printed on sheets larger than A3, however, for the purposes of dissemination these sheets have been split into separate A3 map sheets which fit together to produce a single map of the CD.

Dissemination — order and delivery

The CD and SLA Maps can be obtained from ABS Client Services through a printing service provided by the LIC. Maps can be ordered through the ABS in two forms:

- bound sets; and
- ad-hoc orders (bound or unbound).

Bound sets cover an entire State/Territory or the whole of Australia and are bound into ringed binders. SLA Map sets are bound in SLA code order, and are also supplied with a number of indexes: one indicates the SLA Map in which each CD is located, and another allows the SLA Map to be identified by the name of the SLA it contains, and the final index provides a quick-reference SLA code and name reference. CDs do not have names nor do the CD Maps show any other boundaries, so they do not need indexes. The CD Maps are bound or packaged in CD code order.

Ad-hoc orders for areas smaller than a State/Territory are available, in fact maps for a single SLA or CD can be purchased. Ad-hoc orders can also include any combination of CD or SLA Maps, and can also be bound. Ad-hoc orders have the option of being bound, and in the case of the SLA Maps, indexes are also supplied.

Orders are placed using an electronic ordering system at each of the ABS State Offices, in each State capital, and at Central Office, Canberra. The ordering system connects to the LIC, the map order details are transferred and the maps are printed. Once printing is completed the maps are bound and packaged, and dispatched to an ABS office or directly to the client.

For more information contact the ABS (see Appendix I).

1996 CENSUS CUSTOMISED MAPPING SERVICE

ABS Client Services offer two types of customised mapping services:

- customised thematic mapping services; and
- customised reference mapping services.

The digital geographic data used in these two services are generally 1996 Census Reduced Boundaries and 1996 ABS/PSMA Reduced Base Map, although other data are used where appropriate or required by the client.

To place a mapping consultancy request, contact ABS Client Services (refer to the contact list at Appendix I).

Customised thematic mapping service

Thematic maps are maps that show various geographic regions that are shaded or patterned, or use some other graphic tool (for example, different sized arrows), to convey differences in a particular characteristic. Census data is a particularly popular source of data used for these type of maps as a wide range of characteristics are available for small areas. These areas and the associated statistics can then be aggregated to cover a wide range of differently shaped regions to suit various needs.

Customised thematic maps are available for all the Census Geographic Areas and most client-specified areas. These maps can incorporate statistical data from the census and from a range of other sources. Topographic data, such as roads, railway lines or features like hospitals, schools and towns, are also available for inclusion in these thematic maps.

Customised reference mapping service

Reference maps are maps that show the boundaries and other non-statistical geographic information of particular geographic regions, usually in the context of the topographic features that define them. These types of maps are particularly important when using census data as they help to define the extent of the Census Geographic Areas.

Customised reference maps are available to suit most client needs. These maps contain base map (topographic) data, Census Geographic Areas and/or client-specified boundaries. They do not contain any statistical data and they are not available without ABS boundaries, or derivations thereof.

1996 CENSUS CUSTOMISED GEOGRAPHIC DATA REPORTS

The 1996 Census customised geographic data reports provide clients with tabular geographic data that relates specifically to the Census Geographic Areas. The data available in these reports are taken from the OSD view of the CDRD (see Part B) therefore the reports available can use any of the items listed in Appendix G.

Three types of common geographic data reports can be provided using the following standardised reports:

- direct queries — data from any number of nominated geographic areas can be drawn directly from the CDRD, (for example, the area in m^2 for a number of SLAs);
- geographic conversions — a listing of all the geographic areas of a particular type (for example, an SLA) that are contained within, or share any common territory with,

specified geographic areas of any another type (for example, a State Electoral Division) can be taken from the CDRD; and

- comparability listings — a set of CDs from a previous census year (back to 1976) can have the CDs from the 1996 Census which correspond to them identified and listed. Alternatively, a list of 1996 Census CDs can have the CDs from previous censuses which correspond to them identified and listed. In each comparability listing there is a comparability indicator.

Clients who have data requirements that cannot be met by these three standard reports, or a combination thereof, can have their requests serviced though a special data query facility which is also available.

1996 CENSUS STATISTICAL PUBLICATIONS

Three series of 1996 Census publications contain maps derived from the 1996 Census digital geographic information. These are:

- *Selected Social and Housing Characteristics for Statistical Local Areas* (2015.0-8);
- *Selected Family and Labour Force Characteristics* (2017.0-8); and
- the *1996 Census Social Atlas* series.

APPENDIX A: PREVIOUS CENSUSES

PREVIOUS CENSUS COLLECTION MAPPING PROGRAMS

For the 1991 and previous censuses, the ABS arranged for the production of hard copy maps for collection purposes through a standing arrangement with the Australian Surveying and Land Information Group (AUSLIG) and before this with the Division of National Mapping (NATMAP). The basis of the arrangement was for AUSLIG to obtain the most up-to-date base maps and overlay on them details of updates to the Census Collection District (CD) boundaries as provided by the ABS during the CD design program.

The maps maintained by AUSLIG were in hard copy form (it was not until the 1991 Census that collection maps for some localities were produced by AUSLIG using digitised geographic information). Updating and maintaining the base maps was a labour intensive and expensive task. Due to the cost involved, collection maps were limited to two colours: black was used for all base map information, and red for all statistical boundary information.

The CD design program undertaken in each ABS State and Territory office was also paper based. In most instances, new CD boundary design work was reflected on copies of previous census maps. This design work was forwarded (over a two year period) to AUSLIG where it was transcribed by AUSLIG staff onto the next census base map.

These maps were then used in the collection phase of the Census and returned to the ABS. Some 7500 C3 sized map sheets covering Australia in a grid form, at various scales, were provided for the 1991 Census. These maps then were re-collated and sold to the public as the Census Collection District Map product described in the section Maps — 1991 Census, below.

Hand-in-hand with the CD design process was the creation and update of a computer file containing a record for each CD (see the section Geographic Data Base (GDB) below, for a description). This file was updated independently of the CD boundary redesign process. This meant that the concordance between what is shown on census collection maps and the data file against which the census data would be recorded and disseminated relied completely on manual checking by ABS staff to ensure that:

- there was a record for each CD contained in the collection maps; and
- geographic characteristics of CDs (such as LGA, SLA, Urban Centre/Locality codes, etc.) were correct.

This was labour intensive despite considerable computer edit, validation and consistency checking.

DIGITISED BASE MAP AND BOUNDARIES

For the 1981 and 1986 Census, Census Geographic Area boundaries were digitised and marketed by AUSLIG (or its predecessor NATMAP). The ABS had little to do with the production and marketing of these boundaries, except for the sets included in the CDATA86 product.

For the 1991 Census the ABS contracted Peripheral Systems Pty Ltd (now MapInfo Australia) to prepare the 1991 Census Digital Boundaries and to supply an Australia-wide seamless digitised base map. The boundaries were produced to conform with ABS specifications and the base map, the first of it's type, had to be in a suitable form for inclusion in CDATA91 and CMAP91. The base map included streets, waterways and other features. The boundaries were disseminated by both the ABS and Peripheral Systems (and Peripheral Systems' resellers) to clients. The base map data were disseminated by the ABS and Peripheral Systems in the CDATA91 product, and as a stand alone product by Peripheral Systems.

The dissemination system for the digitised data met with some problems in the preparation of particular industry standard formats. For the 1996 Census the dissemination system for boundaries, described in Part C, is specifically targeted at solving this problem.

CDATA86 AND CDATA91

For the 1986 Census, a CD ROM based product called CDATA86 was developed jointly by Space-Time Research and the ABS. CDATA86 contained statistical data for small area collected from the 1981 and 1986 Censuses, and digitised census boundaries (but no digitised base map data). The product used Supermap software to retrieve, tabulate and map the data supplied.

An enhanced version of the product was made available for the 1991 Census, called CDATA91. CDATA91 provided data on CD ROM which included statistical data in the form of 1991 Census Community Profiles as well as digitised base map and boundary data. Software was also provided as part of the product — a choice of MapInfo for Windows or Supermap for Windows was offered. Both pieces of software supported the production of reference and thematic maps as well as data in tables. The maps and tables produced were able to be exported to other packages, such as; spreadsheets, word processors and desktop publishers. Facilities also existed that allowed new data to be imported into the software. Some time series data from 1986 and 1981 Censuses was also available in CDATA91.

MAPS — 1986 CENSUS & PRIOR

Standard map products

A variety of reference maps and a thematic map for the 1986 Census were produced as standard ABS output by NATMAP. These maps included:

- Statistical Division Maps;
- Statistical Region Maps;
- 1986 Census Field Maps;
- 1986 CD Outline Maps;
- Australia: Statistical Divisions and Statistical Local Area Map 1:5 000 000 scale; and
- Australia: Population Density Map 1:5,000,000 scale.

Customised mapping

Customised mapping for the 1986 Census was limited to thematic mapping using CDATA86 and SASMAP.

Publications

A number of 1986 Census publications, including social atlases, containing statistical data for geographic areas contained both thematic and reference maps. The thematic maps were produced using the same techniques as customised maps, described above, and the reference maps were simply copies of the standard Statistical Division Maps, to which reference was made above.

Before the 1986 Census, the ABS, in collaboration with NATMAP and several other organisations, produced standard sets of social atlases for the 1976 and 1981 Censuses. A standard set of social atlases was not produced for the 1986 Census. Several of the State and Territory Offices of the ABS produced their own social atlases, using SASMAP and CDATA86.

MAPS — 1991 CENSUS

Standard map products

One standard map product, 1991 Census Collection District Maps, were produced from the 1991 Census. These were disseminated either directly or by photocopying. These maps showed the location of CD boundaries superimposed on a black and white topography map. Microfiche containing copies of the maps were produced but not released due to unacceptable quality.

Customised mapping

Customised mapping for the 1991 Census included the production of reference and thematic maps.

A specialised product was also released, called CMAP91, which allowed ABS clients to produce reference maps to their own specifications. It was a software package for Personal Computers using a reduced version of MapInfo for Windows, essentially the mapping component only, which also contained the digitised base map and boundaries included in CDATA91. It was, in effect, an electronic atlas. The digitised data could be manipulated within the package to obtain a customised map on screen. This map could then be output to a printer.

Publications

Reference maps were included in most 1991 Census publications containing statistical data for small geographic areas. These maps were produced specifically for the publications.

Due to improved technology and reduced costs the ABS returned to producing a standard set of social atlases for each State and Territory capital. The social atlases contain a range of thematic maps, incorporating data from several broad topics, and a number of reference maps. The maps cover the Major Urban Area of each Capital City from the States and Territories. The 1991 digitised boundary and base map data were used extensively in the creation of the maps in this publication.

APPENDIX B: THE COLLECTION MAPPING PROGRAM

INTRODUCTION

The ABS Census Collection Mapping Program has three distinct mapping requirements to be fulfilled during the lead up to the Census. These are to:

- review, and re-design where necessary, Collection Districts (CDs) used in the previous Census (over 31,000 CDs were handed over from the 1991 Census);
- provide maps of CDs to collection staff; and
- provide a base map over which statistical boundaries and data from the Census, and other ABS collections, can be displayed and analysed.

DECISION TO REVIEW THE MAPPING PROGRAM

After the 1991 Census the ABS decided to re-evaluate the Census Mapping Program and look for ways to improve the system. This decision came about because of a need to improve the census collectors' maps, and reduce the degree of disparity of technology and duplication of effort between the Census Collection and Census Dissemination Mapping Programs.

CENSUS COLLECTION MAPPING SYSTEM (CMS)

The CMS has as its basis a digital base map, supplied by the PSMA. This base map is overlaid by digital collection management area boundaries which can be manipulated to reflect any required changes. Various data are attributed to those boundaries through an Oracle database called the Collection District Record Database (CDRD) (the CDRD replaces the previous Geographic Databases).

The system was built and used to facilitate:

- the design of collection boundaries;
- production of census collection management area maps which integrated the collection boundaries and the base map data;
- management of information associated with boundaries; and
- storing of the digital geographic information used.

The CMS used the following software to manage and manipulate the data:

- Oracle, as its primary database management system;
- Intergraph's MicroStation, as the graphics engine; and
- MicroStation Modular GIS Environment System (MGE), to link the spatial data to the aspatial data.

The digital geographic information thus produced was incorporated into the Master Spatial Database (MSD) and used to produce the products listed above. This same data will later be used as input into the design process for the 2001 Census.

The easiest way to understand the CMS is to follow the CD design process as it occurred for a Field Management Area (FMA). The FMA of Newcastle is used as the example.

On receipt of the base map data for Newcastle from the PSMA, Candata loaded the data to their system and performed extensive quality assurance procedures. The 1991 Census Digitised CD Boundaries were then also loaded. Along with the boundaries, the associated GDB records were loaded and linked to the boundaries using an attribute table from the Collection District Record Database (CDRD). The boundaries were then aligned to the relevant features in the base map data. During the alignment process any changes to the boundaries resulted in automatic updates to the records in the CDRD. The digital base map, the aligned boundaries, and the CDRD information were then transferred to the ABS.

On receipt at the ABS, a selection of CDs were checked against existing maps to validate the alignment process. On completion the FMA was forwarded to ABS Sydney.

Staff in ABS Sydney then conducted their CD design work using the CMS software. Boundaries were added, removed, or adjusted; creating new CDs and altering or amalgamating existing CDs. These boundary alterations were implemented to take into account changes in the pattern of settlement and land use that had occurred since the 1991 Census. The CDRD was updated automatically when changes were made to the digital boundaries fields on the CDRD not directly related to the CD design process. An example of this would be the allocation of CDs to SLAs.

Once the State office staff were satisfied that CD design for Newcastle was complete the changes were committed to the system.

ABS central office staff then subjected the updated CD boundaries to a series of quality checks. Once the CD boundaries were approved a copy, accompanied by the relevant CDRD data, was down-loaded to Candata. At Candata, the boundaries and the CDRD information were enhanced and reformatted ready for posting to the MSD. The information was then transferred back to the ABS and posted to the MSD.

Candata retained the MSD data and processed it using software developed to produce a map for each CD. Candata then produced high quality copies of each individual CD map. Using similar software Candata also produced maps for Census group leaders (FGA maps) and field managers (FMA maps).

Each FMA (like the Newcastle FMA) for Australia went through a similar process and when completed was added to the MSD and maps were printed. So the basis of the MSD was the data generated by the CMS. Later the MSD was used to store other census aspatial data that was able to be linked to the spatial data. This data included the codes for the Census Geographic Areas and a range of other data acquired during the collection phase, much of which will be used to aid in the design of the 2001 collection areas.

MAIN BENEFITS OF THE CMS

The three most important benefits of the CMS were:

- that it enabled the CD designers to update the CD boundaries for the 1996 Census using a base map that was the most up to date version available;
- by directly linking the CDRD to the boundaries the database could be automatically updated as the CD

boundaries were redesigned; and
- at the end of the design process there was a fully integrated database, the MSD, that was available for use in census geographic products.

Having a base map that was current and would remain fixed throughout the census boundary design process meant that staff doing the design work could be confident that the changes they were making would be permanent and related to the current situation on the ground. Previously they had done design work using outdated maps and had to wait for that work to be transferred to current base maps and returned several months later.

Directly linking the CDRD to the spatial dataset virtually guaranteed that all CDs had a matching database record. These linkages also increased confidence in the information stored against each record as it allowed:

- automatic updating of records during CD design; and
- powerful visual and computer aided validation of the data contained in the database.

A fully integrated database that was produced under direct ABS management meant that the CD boundaries created in the CMS could also be used in the dissemination phase of the Census, rather than having them produced by digitising hard copy maps. Also the same base map features contained in the collection maps and used by the collectors to orientate themselves during the collection phase, could be used in conjunction with the boundary data to orientate users of census geographic and statistical data.

The availability of the MSD meant that a standard representation of the geography of Australia underpinned all the Census. A continuity between collection and dissemination at a fine level of detail was made available, something that had never been available before in the history of the Census.

APPENDIX C: COLLECTION AREAS AND CENSUS GEOGRAPHIC AREAS

COLLECTION AREAS

- Census Collection District (CD)
- Field Group Area (FGA) (previously called Census Subdivisions)
- Field Management Area (FMA) (previously called Census Divisions)

CENSUS GEOGRAPHIC AREAS

Australian Standard Geographic Classification (ASGC) Areas

- State (STE)
- Statistical Division (SD)
- Statistical Sub-Division (SSD)
- Local Government Area (LGA)
- Statistical Local Area (SLA)
- Census Collection District (CD)
- Statistical District (SDIST)
- Major Statistical Region (MSR)
- Statistical Region (SR)
- Section of State (SOS)
- Urban Centre/Locality (UCL)

Other census-specific areas

- Commonwealth Electoral Division (CED)
- State Electoral Division (SED)
- CD-derived Postal Areas (POC)
- State Suburb (SSC)
- ATSIC Region
- Indigenous Locations
- Indigenous Areas

APPENDIX D: NATURE OF SPATIAL AND ASPATIAL DATA USED IN THE 1996 CENSUS

SPATIAL DATA

The digital spatial data contained in the 1996 Census Digital Geographic Databases is vector based. Vector based spatial data represents real world geographic features such as towns, roads and lakes with graphic objects. In their most general form these graphic objects are classified into three categories:

- points;
- lines; and
- areas.

These objects are stored as points and/or lines connecting those points. These points and lines are stored as digital computer data in a form that the computer software, which the data are designed to work with, can understand. The data used to store these graphic objects are referred to as spatial data as its primary purpose is to define the spatial nature of a feature.

Points

Points are the most basic graphic object. They are used to represent the location of features that have a limited geographic extent at the scale at which the digital data will generally be used. In the ABS dataset this includes buildings, such as places of worship or facilities like fire stations, and mountain spot heights.

A point is defined by a single set of geographic co-ordinates, such as a longitude and latitude, which the computer software uses to locate that feature in space. A symbolic representation of the feature is often linked to these points to allow the feature to be represented visually on a computer screen or a hard copy map.

Lines

Lines can be made up of a single line segment, or a number of line segments joined together to form a line string (otherwise referred to as a polyline). Lines are used to represent the location of features that are of a linear nature at the scale at which the digital data will generally be used. Linear nature means that the feature has a geographic extent in one direction, that is, it has length. For example, at a city level, roads will generally be represented by line elements. But at a suburb level, roads will begin to have a noticeable width which may vary considerably. Therefore, representation by a linear element may no longer be appropriate. Powerlines and underground pipes would generally only be represented as line elements at the suburb level.

A line segment is generally defined by a set of two points that are joined by a straight line. A polyline can contain many more points. Each of the points that define the polyline is ordered sequentially. These points are then joined in that sequential order by a line. The beginning and end points of a line are often assigned a specific name, the most common name is a node. Often for visual representation the lines are assigned a specific width (usually referred to as its weight) to indicate the approximate extent of the feature (or alternatively its importance).

Areas

Areas, more specifically referred to as regions or polygons, are made up of a polyline, or a set of polylines and/or line segments, that closes to form a shape. Polygons are used to represent the location of features that have a geographic extent at the scale at which the data will generally be used. For example, at the national level the lines the make up a state boundary when formed together might form a polygon that represents the geographic extent of the state. At a suburb level the co-ordinates that define a property boundary may be used to create a polygon that represents that property.

A polygon is defined by joining the line elements that represent the boundary of an area. As was explained in the previous section these line elements are made up of points and connecting lines, the system uses these to define the extent of the polygon. Polygons can often have a third property apart from the points and connecting lines that define it. This property is the actual space, or area, contained by the polygon. In most systems, including the ABS', this area is not specifically defined from an external source, rather it is derived from the points and connecting lines that define the polygon. This 'area' can sometimes be filled with a colour or pattern to represent some characteristic of that region. For example, it may be coloured to represent the level of population density or patterned to show it is a swamp.

ASPATIAL DATA

A great deal of other information about each feature is linked to the spatial data - this is called the aspatial data. This data is more commonly called attribute data, as it contains particular attributes, or characteristics, of the features in the dataset. For example, an attribute may be the name of the feature or information instructing the software how the feature should be displayed.

The attribute data are stored in attribute tables and are linked to the graphic objects by reference numbers. Each record in the attribute table has a unique reference number attached to it. Similarly each graphic object has a reference number associated with it. The software links these numbers together to determine which attributes are attached to each graphic object.

This initial attribute table can be linked to other tables through the use of additional reference numbers stored in each table. This allows greater flexibility in relation to data storage and increases the operators ability to relate different data to that in the initial attribute table. Generally this extension of attribute tables requires more complex software and greater system operator skills.

In the 1996 Census Digital Geographic Databases the aspatial data is stored in Oracle tables and is linked to the spatial data through MGE (Modular GIS Environment - used in conjunction with MicroStation) using specific fields in the Oracle tables. A similar field, and a pointer to the relevant table, is also stored with each of the geographic elements in the digital spatial data. MGE then uses these fields to link the two data types thereby giving the tabular data a spatial component and providing the geographic elements with more meaning by making a range of data that applies to that feature available.

Two broad categories of data stored as attributes are:

- feature attributes; and
- data processing attributes.

Feature attributes

Feature attributes mainly include the physical or cultural aspects of a feature or graphical object. For example feature attributes that could be ascribed to a road might include; its name, the material it is made from, its age, its condition, the traffic densities it carries, and any number of other attributes. These attributes are stored in an attribute table. In the 1996 Census Digital Geographic Databases, the CDRD contains a number of attribute tables. The CDRD stores information relating to CDs, such as the SLA in which the CD is contained.

Data processing attributes

Data processing attributes are used by the software that manipulates the digital data to enable it to access, manipulate and display the spatial and aspatial data. There are three general categories into which these data processing attributes can be classed:

- linkage data — allow the attribute tables to be joined to the spatial data;
- display data — define how the spatial data should be visually represented; and
- topological data — define how the graphical objects relate to each other spatially and which graphical objects go together to make up each feature.

These three types of data processing attributes are largely invisible to the user and generally are only used by the software.

Each of the 1996 Census Digital Geographic Databases contains a number of tables which incorporate these data processing attributes. The secondary providers selling the 1996 Census Digital Boundaries are responsible for ensuring that these relevant attributes are converted into an appropriate form for the software for which the data are being supplied.

APPENDIX E: DATA QUALITY OF THE BASE MAPS AND BOUNDARIES

MASTER SPATIAL DATABASE (MSD) AND THE OUTPUT SPATIAL DATABASE (OSD)

Base map

Detailed information about the base map and variations in data characteristics are available from the PSMA. For example, the following extract gives all the quality indicators for urban roads in NSW:

Feature	C (%)	PA (m)	LC (%)	LA (%)	L(s)	ID
Highway	95	5	95	99	DCDB	Y
Main road	95	5	95	99	DCDB	Y
Sealed road	95	5	95	99	DCDB	Y

C=Completeness; PA=Positional Accuracy; LC=Logical Consistency; LA=Label Accuracy; L(s)=Main Source; ID=Identified Separately

A complete set (Urban, Rural and Remote) of data quality indicators for all features in the PSMA data set can be obtained from the PSMA (refer to the contact list at Appendix I).

Boundaries

The majority of the Census Geographic Area boundaries align with features included in the MSD base map. Where a boundary is intended to follow a specific base map feature then that boundary is within plus or minus 1 cm (i.e. on the ground) of that feature. This may increase in the case where MicroStation data are converted to another file format — for example, the value increases to 10 cm in MapInfo format. Data quality indicators are provided with ABS digital boundaries.

For users of MapInfo and other mapping packages which limit the number of points which a polygon can contain, some of the higher level boundaries (for example Statistical Subdivision and higher) will exceed the capacity of the software. In this case Shapes boundaries should be used. In the case of CDATA96, such boundaries will be further filtered so that they can be displayed in MapInfo, however, boundaries so filtered will not align with the CD boundaries or the base map features accurately.

At the time of printing this publication, the OSD requires further enhancement before it is possible to derive products of an acceptable quality.

REDUCED OUTPUT SPATIAL DATABASE (ROSD)

Base map

The reduction in positional accuracy of all features affected by filtering can be quantified in terms of a maximum deviation away from the equivalent feature, as represented in the OSD. This is possible because the computer program used to filter the data contained a module that prevented points from being removed from a feature where their removal would result in a new representation of the feature that would deviate more than a set distance from the original representation. This maximum deviation varies from a maximum of 10m (i.e. on the ground) for features in urban areas, to a maximum of 30m for features in remote areas. For example, a line representing a road in an urban section of the ROSD base map would be no more than 10m (on the ground) from where it was originally depicted in the MSD. The majority of filtered features would be far less than 10m from their original position.

Regarding data quality indicators, the only indicators which are different to the MSD are:

- the positional accuracy indicator (as a result of thinning); and
- the label accuracy which may have increased due to the extra validation and checking applied to the labels when they were converted to name attributes. This improvement has not been quantified.

Detailed data quality indicators are included in the CDATA96 documentation, and are provided with sales of base map data.

The ABS has put considerable resources into improving the topological structure of this database (that is, the precise alignment of boundary and related feature points). However, there may be some residual errors which could cause problems in topology in some systems.

APPENDIX F: SOURCE SCALE OF TOPOGRAPHIC DATA IN THE MSD BASE MAP

APPENDIX G: CDRD FIELD LISTING FOR THE OSD

1996 CDRD FIELD LISTING — OSD VIEW

Field	Description	Format
STE	State	N1
FMA	Field Management Area	N2
FGA	Field Group Area	N2
CD	Collection District	N2
CHI	Check Digit	C1
CODE_96CD	Full 1996 CD Code	N7
MSLINK	Graphic element and CDRD link	N10
MAPID	Map Number	N10
SD	Statistical Division	N2
SSD	Statistical Subdivision	N2
SDIST	Statistical District	N4
LGA	Local Government Area	N4
SLA	Statistical Local Area	N4
SR	Statistical Region	N2
MSR	Major Statistical Region	N1
UCL	Urban Centre/ Locality	N5
SOS	Section of State	N1
POC	CD-derived Postal Areas	N4
CED	Commonwealth Electoral Division	N2
SED	State Electoral Division	N4
SSC	State Suburb Code	N3
JTW	Journey to Work	N1
TAREA	Total Area	N10.4
LON	Longitude of Centroid	N3.6
LAT	Latitude of Centroid	N3.6
CD_TYPE	Collection District Type	N2
PSN_M_TOT	Total Males in CD	N4
PSN_F_TOT	Total Females in CD	N4
PSN_OPD	Persons in Occupied Private Dwellings	N4
ATSIC_Region	ATSIC Region	N2
IND_LOCATION	Indigenous Community of approximately 80 persons	N3
IND_AREA	Indigenous Community of approximately 300 persons	N3
C96–91	CD Comparability 1991–1996 (Relational Table)	N1
C96–86	CD Comparability 1986–1996 (Relational Table)	N1

APPENDIX H: TOPOGRAPHIC FEATURES IN THE MASTER AND OUTPUT SPATIAL DATABASES

H.1: TOPOGRAPHIC FEATURES AVAILABLE IN THE MASTER SPATIAL DATABASE (MSD)

Level	**Features**
1	Coastline
2	Major Water
3	Other Drainage
4	Lake
5	Reservoir
6	Major Dam
7	Canal
8	Swamp Outline
9	Subject to inundation
10	Island
11	Tidal Flat
12	Intermittent/Dry Lake
13	Highway
14	Main Road
15	Sealed Road
16	Unsealed Road
17	Vehicular Track
18	Lane/Pathway
19	Railway Line
20	Bridge/Crossing/Ferry
21	Railway Station
22	Airport/Airport Name
23	Jetty
24	Mountain/Hill
25	Facility
26	Minor Area
27	Defence
28	Park/Reserve
29	Mine/Quarry
30	Dunes
31	National Park
32	LGA boundary (note — not census related)
33	Transmission Line
34	Water Centre Line
35	Other Road
36	Sand Ridge
37	Pipeline

40	Minor Road Name — names of: *Other Road (relates to level 35), Sealed Road (relates to level 15), Unsealed Road (relates to level 16), Vehicular Track (relates to level (17), Lane (relates to level 18), Pathway (relates to level 18)*
41	Minor Water Name: *Bend, Billabong, Creek, Elbow, Falls, Floodout, Lagoon, Lake, Pond, Rivulet, Soak, Spring, Stream, Tarn, Waterhole*
42	Railway Name: *Railway/Tramway, Railway (dismantled/unused), Railway Tunnel*
43	National Park Name: *National Park, State Forest*
44	LGA Name (note — not census related)
45	Cultural Name: *Aerial, Ambulance, Bank, Bend, Bore, Breakaway, Cairn, Camping Area, Canal, Caravan Park, Cemetery, Channel, Church, Claypan, Corner, Dam, Drain, Fence, Forest, Gas field, Golf Course, Gravel Pit, Hall, Hospital, Hotel/Motel, Junction, Jungle, Levee, Lighthouse, Mast, Mine, Museum, Numerous small dry lakes, Out-camps, Out-stations, Park, Picnic Area, Pipeline (relates to level 37), Plantation, Pocket, Police Station, Pool, Post Office (PO), Poultry Shed, Power Station, Pump Station, Quarry, Racecourse, Railway Station, Rapid, Recreation, Reserve, Reservoir, Rifle Range, Ripple, Rock-hole, Rubbish Tip, Sawmill, School, Shore, Siding, Silo, Small Town, Spillway, Substation, Swamp, Tank, Tramway, Transmission, Tower, Viaduct, Weir, Well*
46	Suburb Name
47	Highway Name
48	Nil
49	Major Fence
50	Main Road Name
51	Name of Bridge, Crossing, Ferry, Jetty, etc: *Boat Ramp, Bridge, Crossing, Ferry, Footbridge, Ford, Jetty (relates to level 23) , Pier, Wharf*
52	Relief Name: *Bluff, Canyon, Cape, Cave, Chasm, Cliff, Crater, Crest, Desert, Dome, Dunes, Flat, Gap, Gorge, Gully, Headland, Hill, Hole, Hollow, Knob, Knoll, Lookout, Mountain/Hill (relates to level 24), Mountain Range, Pass, Peak, Peninsula, Pillar, Pinnacle, Plain, Plateau, Pocket, Point, Range, Ravine, Reef, Retreat, Ridge, Rise, Rock, Rocky Outcrop, Sand-ridge, Scarp, Split, Spur, Summit, Tableland, Tor, Vale, Valley, Wedge*
53	State/Territory Name
54	Major Water Name: *Bay, Bight, Cove, Creek, Gulf, Harbour, Haven, Inlet, Ocean, Passage, Port, River, Sea, Straight*
55	Swamp Pattern
56	Desert

H.2: TOPOGRAPHIC FEATURES IN THE REDUCED OUTPUT SPATIAL DATABASE (ROSD)

Level	**Features**
1	Coastline
2	Major Water
4	Lake
13	Highway
14	Main Road
15	Sealed Road (Combined into this level is level 35 — Other Roads)
16	Unsealed Road
19	Railway
20	Bridge/Crossing/Ferry
21	Railway Station
22	Airport/Airport name
28	Park/Reserve
31	National Park
45	Cultural Features: *Ambulance (provided by MapInfo)*, *Caravan park (provided by MapInfo)*, *Church (supplemented by MapInfo)*, *Hospital*, *Park*, *Police Station (supplemented by MapInfo)*, *Post Office*, *Reserve*, *School*

Note that the above features can be used with CDATA96.

APPENDIX I: CONTACT LIST

ABS CLIENT SERVICES

New South Wales	Level 5	Inquiries	(02) 9268 4611
	St Andrew's House	Bookshop	(02) 9268 4620
	Sydney Square	Fax	(02) 9268 4668
	SYDNEY 2000		
	GPO Box 796		
	SYDNEY NSW 2001		
Victoria	Commercial Union Tower	Inquiries	(03) 9615 7755
	485 La Trobe Street	Bookshop	(03) 9615 7755
	MELBOURNE 3000	Fax	(03) 9615 7926
	GPO Box 2796Y		
	MELBOURNE VIC 3001		
Queensland	18th Floor	Inquiries	(07) 3222 6351
	313 Adelaide Street	Bookshop	(07) 3222 6350
	BRISBANE 4000	Fax	(07) 3222 6283
	GPO Box 9817		
	BRISBANE QLD 4001		
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	Exchange Plaza	Bookshop	(09) 360 5307
	2 The Esplanade	Fax	(09) 360 5955
	PERTH 6000		
	GPO Box K881		
	PERTH WA 6001		
South Australia	7th Floor	Inquiries	(08) 8237 7100
	Commonwealth Centre	Bookshop	(08) 8237 7582
	55 Currie Street	Fax	(08) 8237 7566
	ADELAIDE 5000		
	GPO Box 2272		
	ADELAIDE SA 5001		
Tasmania	Ground Floor	Inquiries	(03) 6220 5800
	175 Collins Street	Bookshop	(03) 6220 5800
	HOBART 7000	Fax	(03) 6220 5995
	GPO Box 66A		
	HOBART TAS 7001		
Northern Territory	5th Floor	Inquiries	(08) 8943 2111
	81 Smith Street	Bookshop	(08) 8943 2111
	DARWIN 0800	Fax	(08) 8981 1218
	GPO Box 3796		
	DARWIN NT 0801		
Australian Capital Territory	9th Floor	Inquiries	(06) 252 6627
	FAI HOUSE	Bookshop	(06) 207 0326
	197 London Circuit	Fax	(06) 207 0282
	CANBERRA CITY 2601		
	PO Box 10		
	BELCONNEN ACT 2616		

PUBLIC SECTOR MAPPING AGENCIES (PSMA)

New South Wales	General Manager Land Information Centre Panorama Avenue BATHURST NSW 2795	Phone Fax	(063) 328 204 (063) 322 320
Victoria	Director Office of Geographic Data Co-ordination 436 Lonsdale Street MELBOURNE VIC 3000	Phone Fax	(03) 9603 9100 (03) 9603 9199
Queensland	Director Surveying and Mapping Department of Natural Resources Locked Bag 40 Coorparoo Delivery Centre COORPAROO QLD 4151	Phone Fax	(07) 896 3118 (07) 896 3765
Western Australia	Director of Mapping and Surveys Department of Land Administration Midlands Square MIDLANDS WA 6056	Phone Fax	(09) 273 7047 (09) 273 7676
South Australia	Director Resource Information Group Department of Environment and Natural Resources GPO Box 1047 ADELAIDE SA 5001	Phone Fax	(08) 8226 4812 (08) 8226 4936
Tasmania	General Manager Department of Environment and Land Management GPO Box 44A HOBART TAS 7001	Phone Fax	(03) 6233 3568 (03) 6233 3717
Northern Territory	Director Land Information Division Department of Lands, Planning and Environment Nicholls Place Cnr Cavanagh and Bennett Streets DARWIN NT 0800	Phone Fax	(08) 8999 7027 (08) 8999 7750
Australian Capital Territory	General Manager Australian Surveying and Land Information Group PO Box 2 BELCONNEN ACT 2616	Phone Fax	(06) 201 4265 (06) 201 4368
	General Manager Land Information Office Department of Urban Services GPO Box 1908 CANBERRA ACT 2601	Phone Fax	(06) 207 1946 (06) 207 1944

APPENDIX J: CENSUS WORKING PAPERS

RELEASED

93/1 A study of the Performance of Sequencing Instructions in the 1991 Census

93/2 Comparison of Self-coded and Write-in Responses: July 1992 Test

93/3 1991 Census Data Quality: A Study of Posted-in Forms

93/4 1991 PES (Post Enumeration Survey): Comparison of Census and PES Responses

93/5 1991 Census Public Communications: A Marketing Approach

93/6 1991 Census Data Quality: Aboriginal and Torres Strait Islander Counts

94/1 1991 Census Data Quality: Labour Force Status

94/2 1991 Census Data Quality: Education

94/3 Disability Census Test: November 1993

94/4 Testing of Ethnic Origin Questions for the 1996 Census

95/1 1991 Census Data Quality: Housing

96/1 1991 Census Data Quality: Income

96/2 1996 Census Form Design Testing Program

96/3 1996 Census of Population and Housing: Digital Geography Technical Information Paper

FORTHCOMING

96/4 1996 Census of Population and Housing: Fact Sheets

If you would like a copy of any of these papers, or have any other queries, please contact Julie Evans,Census Development and Evaluation, on (06) 252 5854.